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A CONCEPTUALISATION OF FIRE SUPERIORITY
FOR GREATER REALITY AND CREDIBILITY OF
COMBAT MODELS

Falk Falkenstein Von Fabeck

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THESIS

A CONCEPTUALISATION OF FIRE SUPERIORITY
FOR GREATER REALITY AND CREDIBILITY OF
COMBAT MODELS

by

Falk Falkenstein von Fabeck

September 1979

Thesis Advisor:

J.G. Taylor

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A CONCEPTUALISATION OF FIRE SUPERIORITY FOR GREATER
REALITY AND CREDIBILITY OF COMBAT MODELS

by

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September 1979

ABSTRACT

Formal combat models are a means for military analysts and planners to support decisions concerning military projects. The reality, validity and credibility of combat models is still a controversial subject. This paper provides a discussion of the process of gaining fire superiority in combat. Three different input parameter categories - tactical, technical, and human parameters - were selected to serve as combat input. The combat environment transforms these inputs into combat outputs (or combat effects) in the form of operational, target and human effects. Human effects are the suppressive or psychological effects, whereas target effects are only physical effects. A conceptual model of fire superiority is developed from a theoretical definition of fire superiority.

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I. INTRODUCTION

A. CREDIBILITY PROBLEMS OF COMBAT MODELS

Although Operations Research has developed formal combat models that are in active use today, these models have not always been readily accepted by both military analysts and planners, because of certain difficulties that are inherent in any combat model. Today's spectrum of formal combat models reaches from small-scale, small-unit-action models to aggregated large-scale theater-level models. Hierarchies of models have even been developed; and in such model hierarchies, the outputs of small-scale analytical models have been used as inputs into large-scale analytical models. Modeling efforts were initially intended to yield "point" solutions to specific combat problems. Later, because of the infeasibility of this goal, they simply provided insight into battle dynamics, FEBA movement, force structures, equipment, weaponry, weapon mixes, tactics and doctrine. Generally speaking, combat models have provided insights into battle without having a war.

The question at hand is, whether the models are reliable and credible enough to produce useful and realistic results which may later influence defense-planning decisions. The problem has been to incorporate the qualitative factors, that military experts feel are decisive in combat operations, into a mathematical model. This means: Is small scale combat understood clearly enough and is sufficient detail incorporated into models? This is also reflected in

the need for a theory of combat , a better systematical understanding of combat. Taylor [Ref. 1] and the analysis community consider the development of such a theory to be a necessary prerequisite for any really viable model. Another problem with combat models is their verification. The general scientific approach to proceed from a hypothesis through experimentation to theory is, for very obvious reasons, impossible with respect to combat operations. Therefore, two major alternative approaches to verification have been used; the internal consistency check and the empirical professional judgement. Unfortunately, the latter has a strong bias towards the preferences and point of view of the judging person. The willingness to accept any model solution or outcome at all depends on the degree of probability that the model outcome is realistic. Unrealistic results are not proof of the invalidity of the theoretical approach to combat. It should not discourage the attempt to conceptualize real life problems, since modern military thinking is now based very strongly on scientific research and has received very valuable impetus, trains of thoughts and concepts in this way. Unrealistic results of models may only show that the model inputs have to be amended.

This thesis examines combat, in particular the fire fight, in a rather basic way. The combat process is viewed from the "total systems" approach and a conceptual model of fire superiority is developed.

B. STATEMENT OF THE PROBLEM

It is the author's hypothesis that land combat in general and small-unit fire fights in particular are normally won by fire superiority. It seems to be obvious

that either having fire superiority or gaining it against an enemy force is the key to success in many (if not most) military operations. This is loosely implied and explicitly stated in the German Tactics Field Manual "HDv 100/100, Fuehrung im Gefecht" [Ref. 2] in the chapters about defense and attack. Interestingly enough there is apparently no appreciation of this fundamental hypothesis by model builders, since according to the best of the author's knowledge this important phenomenon of fire superiority has not been so far either implicitly or explicitly considered in any combat model. Other important factors, responsible for battle outcome, are widely considered as e.g. movement, detection, attrition and suppression, to name but the more important ones. Presumably the reason for this is the desire of the modelers to keep the models simple and accessible as well as minimizing the difficulties in quantifying the determining variables and states in the combat situation considered. This significant omission is probably due to the lack of any conceptual model of fire superiority. This situation itself is caused by the absence of any useful definition in the military literature which could serve as a basis for investigating the contribution of fire superiority to combat effectiveness. The German field manual "HDv 100/900, Fuehrungsbegriffe" [Ref. 3] which defines the major terms of current military usage, omits any mention of fire superiority with the explanation being given in the preface that: "It has been renounced to define terms which are self evident without explanation". For very similar reasons a definition of fire superiority cannot be found in the "Dictionary of Military and Associated Terms" published by the Joint Chiefs of Staff of U.S. Department of Defense.

The question obtrudes on the author that if it is so self evident, what is exactly meant by fire superiority. The lack of any existing widely-accepted definition leaves a wide space for interpretation. Fire superiority seems to be

too comprehensive to allow two persons to have the same conceptual basis, though commonly the major aspects, physical and sometimes also non physical components of fire superiority are agreed upon.

Even Armies of different nations seem to have different conceptions of fire superiority. In the case of the Germans and the Americans this may arise from traditional differences in military thinking. Apparently it roots in different concepts of combat. The Germans use the command concept of mission tactics and tend to emphasize manpower aspects of fire superiority, whereas the Americans tend to use that of order tactics and rely more on the bare firepower aspects of fire superiority.

An Army wants to win any battle. Therefore it must know the variables which determine the gaining of fire superiority. In order to influence the battle outcome towards the desired results, an Army must know which of the combat input variables can deliberately be picked and changed. For these reasons it seems to be necessary to have at least a description of fire superiority, if not a conceptual model.

The analyst dealing with fire superiority must try to reconstruct the internal wiring of the "black box" called combat. Combat inputs are transformed in this "black box" into combat outputs, also called combat effects. Because of this importance the analyst is also forced to have a meaningful conceptual definition as a basis for a scientific approach to his modeling efforts.

The goal of this thesis is to increase the military OR community's understanding of fire superiority by describing fire superiority, analyzing it, and then developing a conceptual model. Hopefully, this investigation (both its analysis and conceptual model) sets the stage for future work, possibly even the development of a quantitative model of fire superiority. Thus, better combat models might be developed for defense planning purposes.

C. LIMITATIONS OF THIS WORK

Fire superiority is an extremely complex phenomenon. It exists whenever a battle is fought, whether in large scale operations or in small scale combat. Large-scale combat is characterized by the size of the force involved, by the variety and magnitude of weapons employed, and by the fire power delivered. This distinguishes large-scale combat from small-scale combat. The latter possesses greater homogeneity of units and weapons. This results in relative uniformity of the fire fight at the small unit level. Closer scrutiny, however, reveals that the large scale combat is similar to small scale combat if a small enough sector of the battlefield is considered. Weapons and armor may be individually different, of course, but the characteristics are approximately the same. Therefore a description of fire superiority in general can be attempted, because the mechanics and human reactions of both large and small-scale combat are almost identical.

The scope of this thesis will be restricted to the relatively simple and clear cut battle cases of attack, defense and a meeting engagement. Aspects of fire superiority in small-scale combat, with heterogeneous weapons and supporting fire, will not be considered. The cases of withdrawal and delay are not taken into consideration because of the difficulties in associating fire superiority with one of the fighting parties. Of course, non fighting missions such as reconnaissance or unopposed movement are excluded as well.

An extensive DDC literature search and additional search by the author in the NPS library have yielded no references relating to this important topic. Thus, a listing of research studies, literature, or modeling approaches is impossible. Work dealing with the investigation of fire superiority has been initiated, however, by the Deputy Chief of Staff for military operations (DAMO-ZD), Headquarters, Department of the Army¹.

¹ This fact was communicated to the author during a telephone conversation with LTC F. Gill, Headquarters, Department of the Army (DAMO-ZD), on July 18, 1979.

II. THE PHENOMENON OF FIRE SUPERIORITY

A. GENERAL VIEW OF FIRE SUPERIORITY

Usually, whenever someone defines fire superiority, it is described as the state resulting from the physical effects of firing weapons in combat. Additionally people sometimes include the psychological effects of fire. Suppression studies have indicated that psychological effects are considered to be integral part of fire superiority. However, this is nowhere explicitly stated in the documentation of modeling attempts. Apart from this, no such understanding of fire superiority with its complex spectrum of distinct factors and variables exists. This is because the influence of human parameters is almost never mentioned. To provide an initial point of departure, the definition of M. B. Garber and P. S. Bond [Ref. 4] will be helpful:

A fire which is superior to that of the enemy in volume or accuracy or both and whose effect is to render the enemy's fire less effective. Fire superiority is relative and is a moral phenomenon although largely dependent on physical effect. Fire superiority for the attacker is implied if he is able to advance against the defender without ruinous losses. Fire superiority for the defender is implied if he is able to hold his ground and check the attackers advance.

One should also be aware that fire superiority depends on the social and cultural values of the soldiers engaged in combat. This means that the perception of having achieved the state of fire superiority depends on the value a society attributes to human life, i.e. how many losses can be incurred in order to achieve fire superiority or before fire superiority is lost.

B. THE ROLE OF FIRE SUPERIORITY IN BATTLE

Starting with the above definition, the author would like to present his perception of fire superiority. Its location in the complex structure of combat is based on the individual's view of combat as seen from his perspective with varying degrees of resolution. These varied perspectives, of course, yield a view of combat composed of different factors and parameters. See Fig 1 .

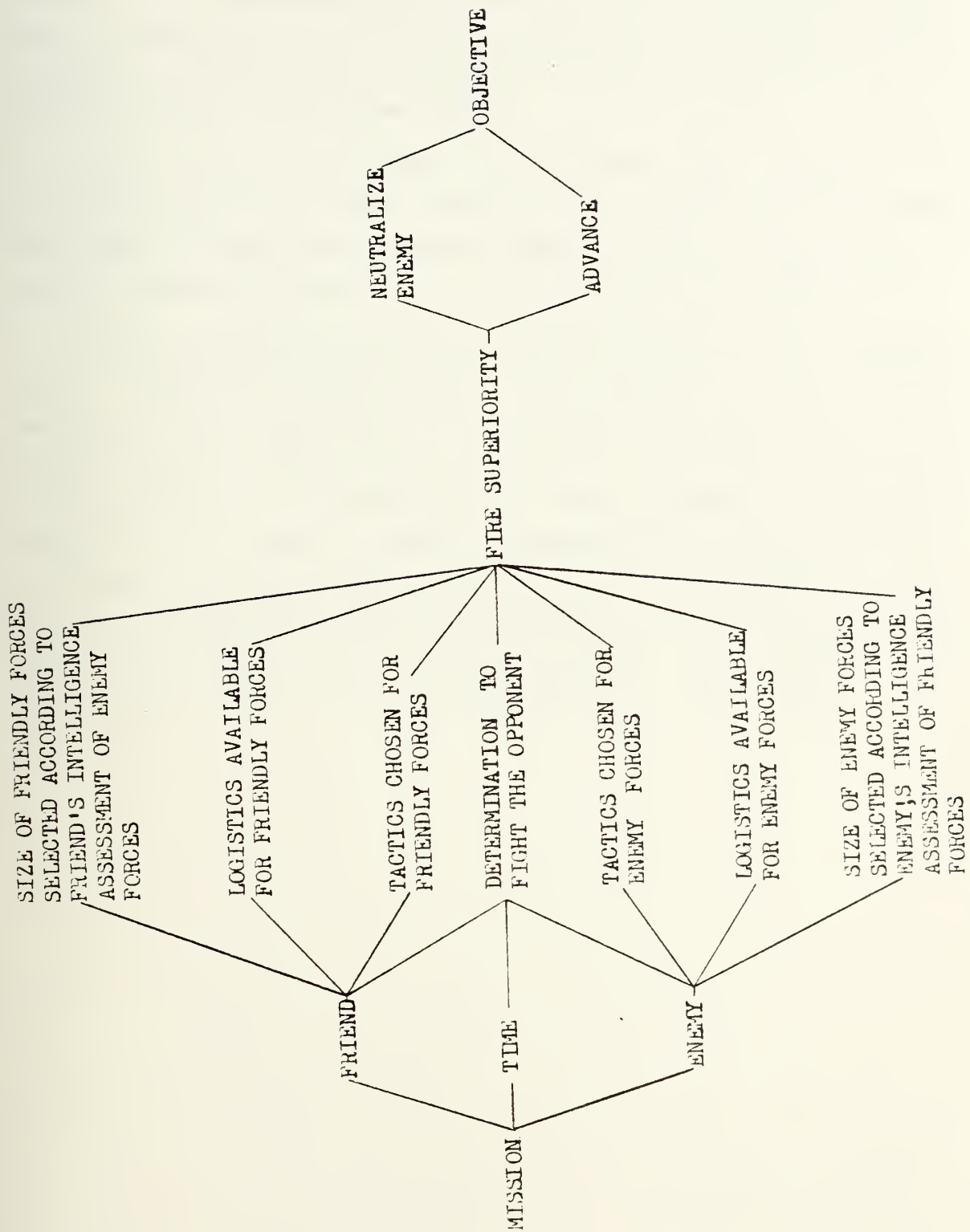


Figure 1 - IDEALIZED STRUCTURE OF COMBAT

When one ideally considers combat, he will notice the mission - objective relation. Missions govern the battlefield, i.e. create the canalized and synchronized violence. They usually specify an objective which has to be achieved within some time limit.

After a closer look one can discern two sides. The friendly and the enemy side are opposed to one another according to their respective missions and strive to achieve their respective objectives in the preset time frames.

A further look reveals the sizes of the forces engaged, their logistic capabilities, and their chosen tactic to neutralize the opponent, i.e. to eliminate the obstacles which impede the achievement of the objective and thus the fulfillment of the mission in a timely manner. Generally speaking, the enemy's mission (objective) is to prevent the attainment of the mission (objective) of the friendly side. This is especially true in the case of small unit-combat after meeting the enemy. In other words, the missions as well as the objectives are antagonistic. See Fig 2 .

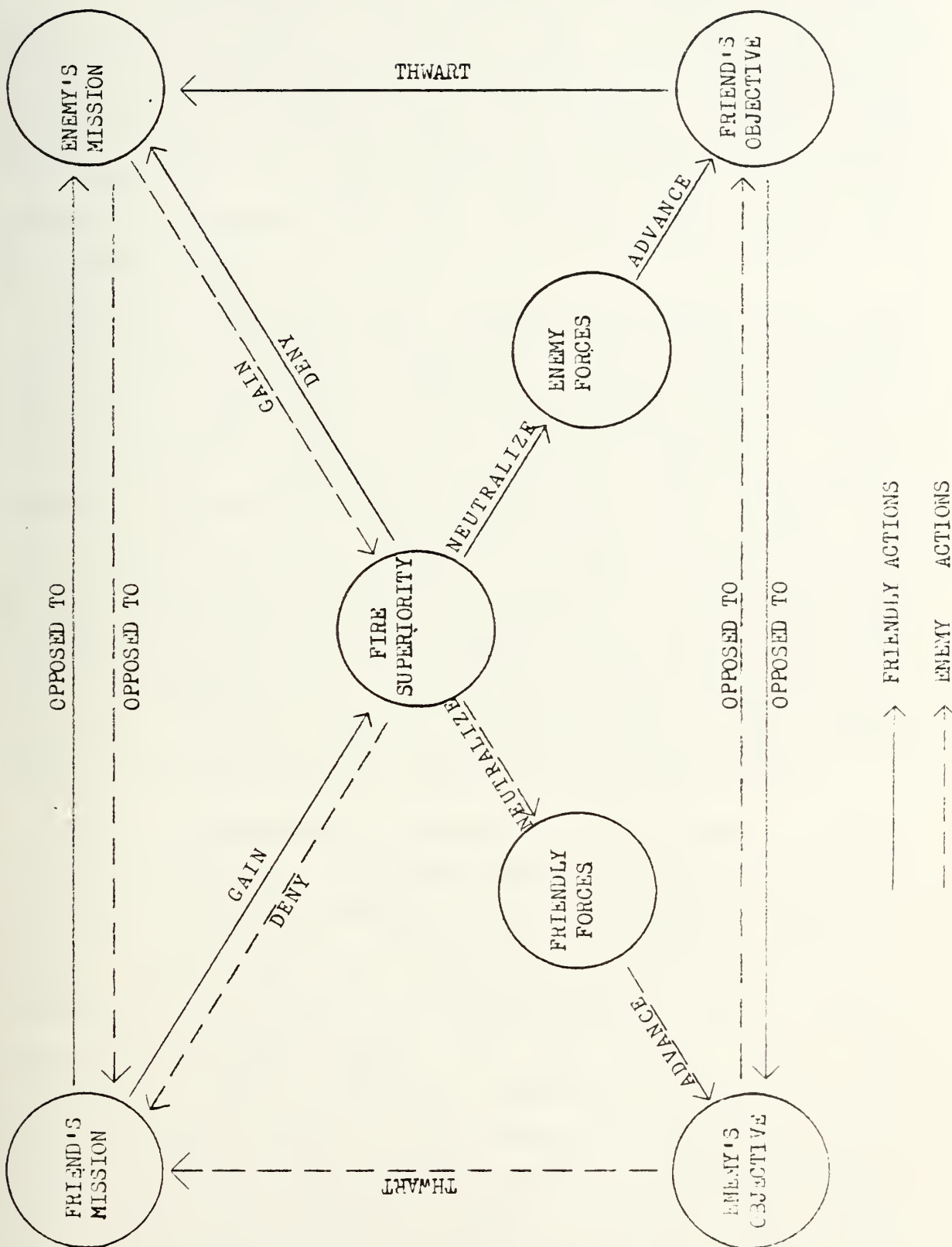


Figure 2 - MISSION - OBJECTIVE RELATION IN COMBAT

Yet a more detailed look reveals an interesting insight. One finds here that at a certain step or level the only remaining battle determinant to achieve the objective is the gaining of fire superiority, as figure 1 shows. This dominant role of fire superiority is shown in figure 2 as the crossover of enemy and friendly fire. Thus the essential elements or factors in combat would appear to be fire superiority.

Another interesting idea results from figure 1. As soon as the initial tactical estimates, as well as the existing materiel on hand, have determined the size of the force to engage the enemy, these factors become invariable at the instant combat commences. Initial force size can only be changed or reinforced after reconsidering the inputs that fire superiority can or can not be achieved with the present force ratio. This idea of fixed initial force sizes and missing reinforcement of units complies with the view of the Lanchaster analytical combat models. It may also be seen that fire superiority is a relative phenomenon dependent on the sizes of the two opposing forces involved, the tactics applied, and the supplies available to the two forces.

Thus it is possible to attribute the key role in combat to fire superiority. Fire superiority is the key to success in either level of command. The Commanding General is concerned about fire superiority as well as the Platoon Leader. Battle from the General's point of view is a sequence of multiple and simultaneously occurring combat scenes with variable inputs in force size, tactics and logistics. For the Platoon Leader all these factors are initially fixed and can not be readily influenced during the period of initial enemy contact, unless the platoon receives reinforcements or supplies. Figure 1 yields a very useful conceptual idea of platoon level combat if one replaces all the developing factors by the initial factors of force size, logistics and tactics for the friend's side as well as for

the enemy's side. Since the investigation of fire superiority in small scale combat shows congruence of the large and small-scale combat, only platoon level considerations will be pursued further on without loss of relevant detail.

C. COMPONENTS OF FIRE SUPERIORITY

The next steps in the investigation of fire superiority deal with the questions, "what is fire superiority, what is it composed of, what situations, variables or factors influence it?" Because of the nature of fire superiority, this part will be mainly descriptive. The multilayer complexity of fire superiority simply does not allow one to factor or subclassify terms and factors in a very clear cut manner. The different terms and factors have correlations and interdependencies which make it difficult to decide which term or factor influences which and in which logical sequence. It is extremely difficult to make distinctions between these different factors. Very often the limits where one factor ends and another begins are not clear. For the sake of clarity and better understanding, as well as for the purpose of factorization of parameters, these distinctions have been made (though sometimes they may appear somewhat artificial). This is, as initially mentioned, a tribute to simplicity. Furthermore difficulties arise from the fact that the enemy's inferiority implies a friend's superiority. That is the friend's more effective fire, relative to or minus the enemy's less effective fire, makes up fire superiority. Lastly, but most important, is the fact that the real world problem has interdependencies and mutually influencing factors which the model can not represent.

Fire superiority may be considered to depend on three parameters. These are tactical, technical, and human parameters. They all have to be viewed as battle input. They can be quantified totally, partially, or not at all, but are qualitatively known to the military to have a considerable influence on battle outcome. Although not readily quantifiable, some parameters are known well enough - not only to experienced combat veterans - but also to analysts so that an attempt could be made to at least rank order or classify them on an ordinal scale.

Tactical, technical and human parameters can conveniently be described through the use of a tree diagram. They are the initial branches which originate in the stem, called fire superiority. Each of these main branches has other subclassifying parameters with further sub-branches.

During the course of a battle the combat inputs are transformed into combat outputs. The inputs determine the level of fire superiority achieved, while the outputs reflect their impact.

1. The Tactical Component

The tactical parameters are the first group of factors which contribute to the gaining of fire superiority. They consist of the mode of combat, the organization, intelligence, and mobility. Because of combat action restrictions, the combat mode consist of attack and defense only. The organization is described best by personnel and material strength, force structure, deployment of units, and supply and logistics. Intelligence is based on the accessability of information via sensor hardware and on the reconaissance capability. Mobility is determined, as before, by the terrain, weather and transportation hardware. tactical parameters may be considered environmental factors in combat. Since the examination of fire superiority has been restricted to platoon level engagements, it is convenient to consider these combat inputs as initially fixed. In the period of time immediately following a small unit's engagement, the initial battle situation or environment does not change, however, of course, battle losses will decrease the initial quantity of personnel, material and supplies on hand. However, under the conditions of battle, the tactical parameters are transformed and contribute to combat output in the form of operational effects.

2. The Technical Component

In a similar fashion the second group of combat inputs, the technical parameters, may be subdivided into subclasses, which are essentially part of the principles of war: namely, Mobility, Communication, and Firepower.

Mobility depends upon the terrain, the weather and means of transportation. Terrain is determined by the topology and foliage cover which yields fire positions, cover and concealment and trafficability. Weather, described very rigidly by humidity and temperature influences trafficability and may also contribute to cover and concealment. The transportation hardware is defined by the vehicle characteristics of armor protection, transportability, engine capabilities and whether the vehicle is selfpropelled or wheeled. The latter qualities may also give protection by outmaneuvering the enemy's fire, thus reducing the vulnerability of the combatant. Mobility also belongs to the category of tactical parameters.

The communication hardware set is composed of both communication capabilities as well as countermeasure capabilities. Further delineation of the communication branch into subsequent subsets did not yield any relevant insights other than an unnecessary differentiation of communication equipment. Therefore it will be eliminated from further consideration.

Firepower is also based upon the capabilities of the hardware. As such it is determined by the ammunition, by the guns or launchers and the sensors. The lethality of a gun is determined by the caliber of the ammunition, the fragmentation characteristics of the projectile, as well as the range of the weapon itself. The resultant intensity produced by the cadence and accuracy of the gun are, of course, influenced by the state of training of the gunner as well as the accuracy of the sensors to acquire targets.

The lethality and intensity of the fire is conveniently collected under the term target effects, which are obviously combat outputs.

3. The Human Component

The third group of factors, human parameters, are a very important but often neglected group of factors.

Battles can not be won by machines without the soldier who forcefully strives towards his objective. The best equipped Army is useless unless the soldiers possess certain qualities which enable them to fight effectively. These qualities are part of almost every man in a more or less distinct form. Individual, as well as group behaviour, depends largely on these factors.

Group factors represent combat-unit parameters which appear to be a sort of sociological factor that consist exclusively of social bounds and behaviour forms like esprit de corps, comradeship, feeling of solidarity, teamwork and physical communication in combat. The importance of physical communication is emphasized by S.L.A. Marshal [Ref. 5] in his book "Men Against Fire":

A chief fault in our men is that they do not talk. They are not communicative. In combat they are almost tongue tied. In Europe they were frequently astonished at the incessant talking and shouting that went on among the enemy formations during an action. They mistook it for naivete in the Japanese that in combat they frequently acted in the same way. That there was a direct connection between these methods and the phenomenal vigor with which our enemies organized and pressed their local counter attacks seems scarcely to have occurred to our side.

Individual factors are a collective term for combatant parameters and leadership parameters. These parameters characterize, and also qualify, the two distinct groups of persons and their personalities in a combat unit. Individual factors often are the reason for the success or failure of an action.

The soldier, who is under fire, is the weakest and also the most influenced link in the chain of combat. His reactions depend largely on his training, experience, morale, and toughness. Of course all these factors in turn depend on other distinct factors. These in turn may be influenced by the battle impressions and may or may not undergo a change in quality during combat periods.

A soldier is trained to show independence in his decisions and actions, to possess initiative, and execute those skills with flexibility. He is schooled in discipline, reliability and obedience. His morale is based on his self-confidence; spirit and mood. His stamina or toughness is determined by his need for rest and comfort and by his insusceptibility to the influence of environmental conditions. Physiological effects in the soldier may be caused by fatigue, stress, strain, danger, threat, climate, weather, temperature, humidity or enemy fire. A soldier's toughness is furthermore dependent on his steadfastness in situations replete with surprise, deception, disorganisation and his steadfastness despite the intensity of battle and the resulting confusion. Self confidence is based on the feeling of eliteness, or superiority or inferiority to the enemy, as well as on the trust in one's knowledge and leadership. Self-confidence is mainly derived from previous experience. The same pertains to the spirit which is dependent on the soldier's willingness, determination, motivation, bravery, courage, self-discipline and self-estimation. The mood of a soldier is determined by his recent experience of success or failure, by his mentality, aggressiveness, anger, fear, rage, despair, panic or even paralysation. During a short fire fight all these factors which influence morale can be considered fixed, but during a long battle all these "morale" factors are variable and thus can heavily influence the battle outcome.

The combat leader must have in addition to the characteristic qualities of the combat soldier, leadership qualities. These include tactical skills and craftsmanship as well as flexibility, which is marked by the ability to improvise if necessary and to adapt his command to changing situations. He must possess a personality which shows ingenuity. He must be accepted as a leader-model by the men of his command. The leader must always be master of the situation and able to exert self control.

The human parameters described hereto are all considered to be combat input parameters . This presentation might be enriched by further factors not yet considered, but it is also clear that the abundance of distinct and different factors shown strongly suggests that much more attention should be paid to the human parameters. This is the more since it may be that these human factors are not at all constant; possibly not even during the short time frame of a combat action. A person endowed with all these attributes when shot at will show human effects which unquestionably fall into the category of combat output.

Psychological effects may also be produced by actively delivering firepower. They may cause a feeling of material superiority, activity and satisfaction and may help to overcome a momentary weakness of morale and confidence. They should not be confused with the psychological effects involved when fire is drawn, and which can increase or offset the effect of enemy fire.

D. COMBAT EFFECTS

The combat activities which comprise the human, technical and tactical factors together in battle will transform the combat inputs into combat outputs by producing effects which will be called human, target, and operational effects. This section scrutinizes the combined effects of operational, target, and human effects. The latter are obviously human reactions to enemy fire in the combat environment. A look at a simplified schematic model of a section of combat interaction will facilitate a better understanding of the ideas involved. See Fig 3 .

The antagonistic missions of friend and enemy permit them to move under some time constraint towards their respective objectives. Objectives contain enemy targets. Targets consist of a firer, a weapon or both. Fire that hits targets can attrit, wound or damage, and thus produce physical target effects. Fire that misses targets forces the soldiers close to the impact point to undergo certain reactions, and thus it produces psychological target effects.

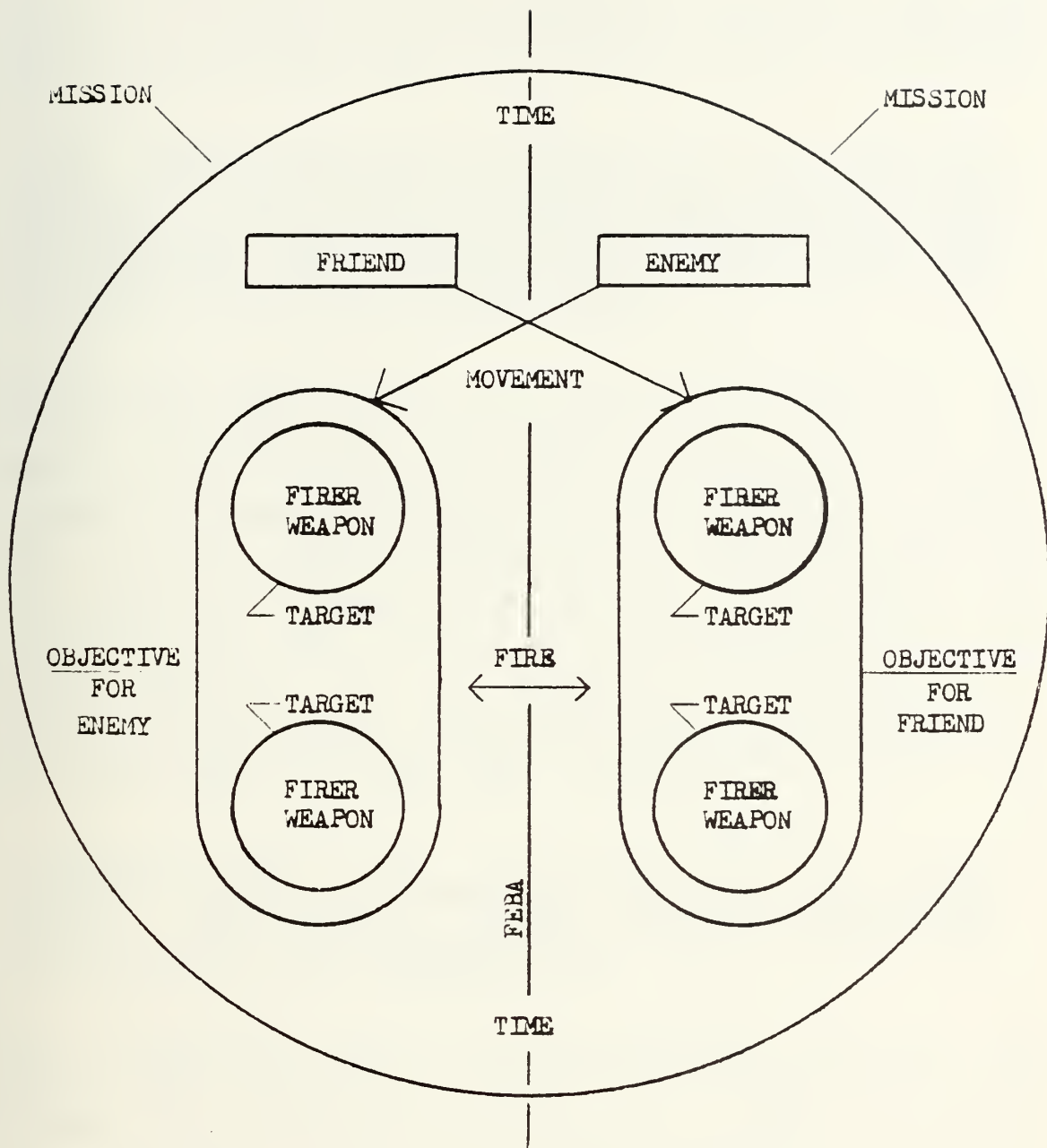


Figure 3 - SIMPLIFIED SCHEMATIC MODEL OF A SECTION OF COMBAT INTERACTION

Fire effectiveness may therefore be split into two causative components. The Psychological Research Associates [Ref. 6] put it this way:

Fire effectiveness may be divided into two components: physical and psychological effects of fire. The physical effects of fire are to kill or to wound and thus reduce the number of enemy who are able to return fire. The psychological effect of fire is to neutralize the enemy and thus reduce the amount of battle time during which the enemy is willing to return fire.

Psychological effects will be produced initially by the senses, specifically the visual, audio, tactile, and orfactory keys resulting from the impacting bullet or shell, whether it misses the target or by the actual physical effect of hitting another nearby target. The perception of that happening induces a fear of being killed and thus forces the individual to a certain behavior depending on his psychic hardness. In his report on an "Investigation of Chinese and North Korean Soldier Reactions to UN Weapons in the Korean War" L. A. Kahn [Ref. 7] concludes:

The major reason given to reaction to all weapons studied is that of casualties; to lesser extents are noise, efficiency of action, burning (considered distinct from casualties), restriction of activities, invulnerability and miscellaneous.

These conclusions are to be expected from intuition. Of course, they reoccur in almost all definitions for suppression, such as the one of George M. Gividen [Ref. 8]

A state of relative ineffectiveness or incapacitation of the individual soldier which is a function of psychological factors and which is either initiated or maintained by a perceived threat from weapons fire.

Gividen also distinguishes five different kinds of suppression which are consequences of different tactical situations and of different types of fire. Since the degree of suppression depends on this as well as on the

psychological stability of the soldier, a closer look into these five dimensions of suppression seems to be necessary in order to understand the mechanics involved in gaining fire superiority.

1. Reasoned (rational) suppression versus unreasoned (irrational) suppression. In the first case, the soldier stays cool, keeps his head down and rationally analyzes and calculates the situation and his survival probability. This is opposed to the second case, in which the panicking soldier does not consciously consider the real nature of the threat or its long term effects.

2. Area suppression versus point suppression. It can be best described by randomly distributed machine gun fire over an area, or even mortar fire as opposed to the aimed fire of a sniper. The weapon best suited for point suppression may be useless for area suppression and vice versa.

3. Defensive suppression versus offensive suppression. Defensive suppression can be obtained most effectively against attacking infantry by machine gun fire, whereas the offensive suppression to support an attack can be best obtained by mortar fire.

4. Lethal suppression versus denial suppression. Lethal suppression neutralizes an enemy's movement and actions in the area in which he is caught by fire, whereas denial suppression keeps him out of heretofore unoccupied areas.

5. Direct fire suppression versus indirect fire suppression. This dimension is characterized by the firing characteristics of direct firing weapons, as opposed to the indirect firing weapons.

For the sake of completeness the following sixth item should be added to the above:

6. Permanent suppression versus no suppression. A soldier who has been killed, severely wounded or suffered severe psychological shock can not engage in further combat and is considered permanent suppressed. This is in opposition to a soldier who experienced no effective suppression and is therefore undegraded.

These distinctions of suppressive situations and the kind of weapons and fire involved reflect the multitude of possible psychological processes in soldiers under fire. Further information about suppression may be found in the report of the Army Scientific Advisory Panel Ad Hoc Group [Ref. 9] which provides a: "Schematic description of the sequence of processes that are conjectured to occur in a single time slice when suppressive fire is delivered and affects combat results." See Fig 4 .

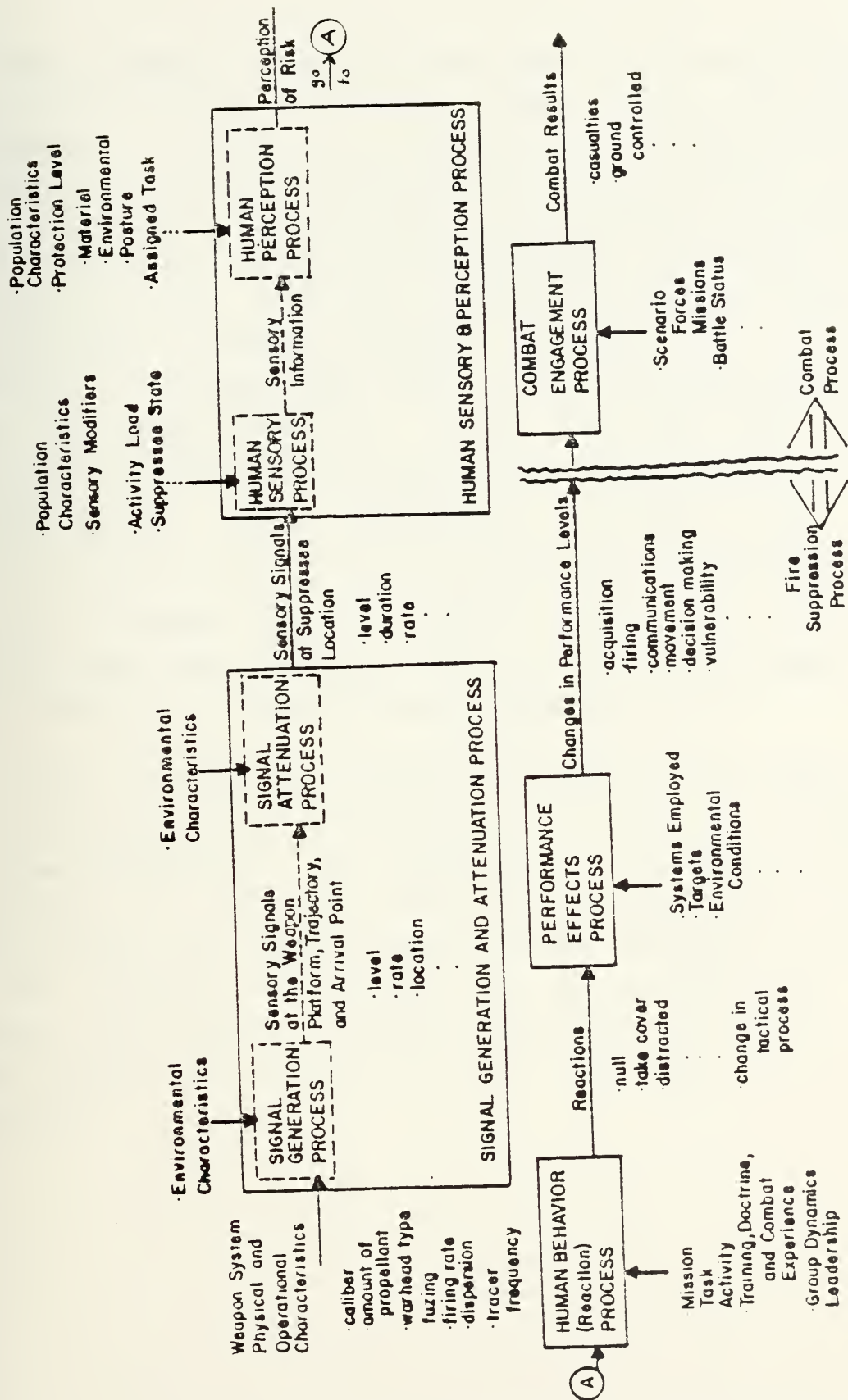
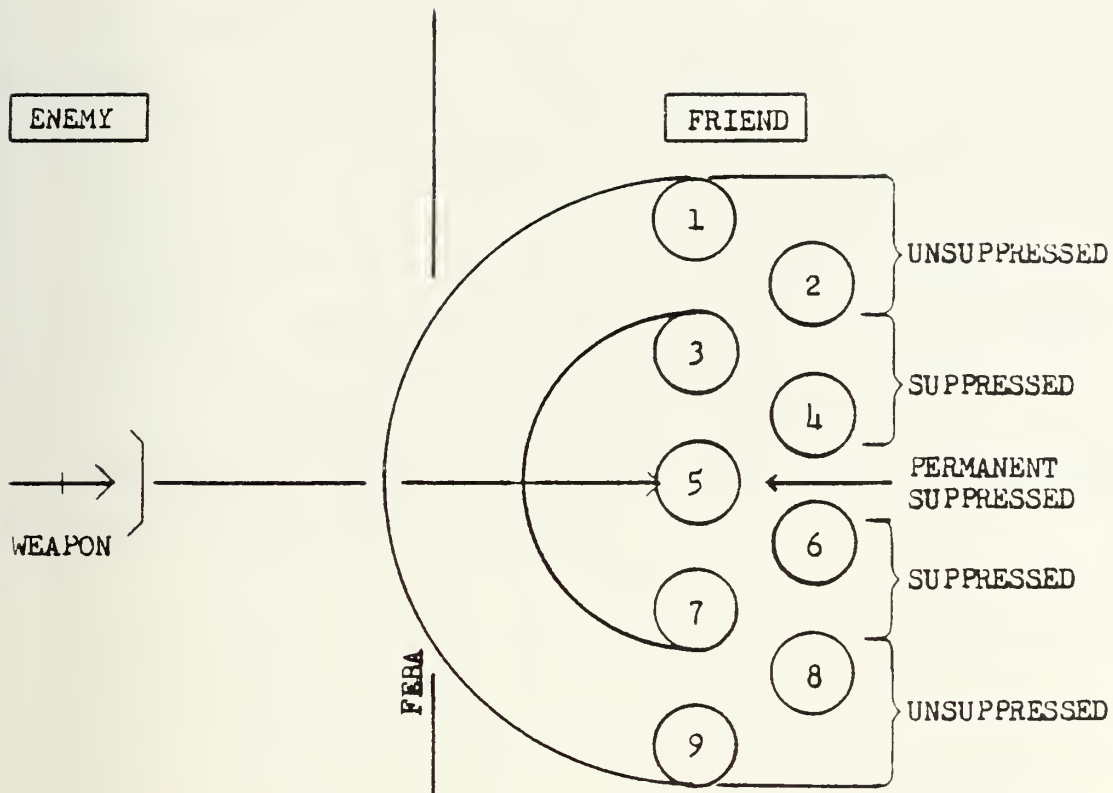


Figure 4 - GRAPHICAL REPRESENTATION OF THE SUPPRESSION PROCESS

The symptoms of suppression may also be illustrated from the point of view of battle stress and the human performance. Stress, per se, is not harmful unless it exceeds certain tolerable dimensions. They are reached when the individual's actions begin to be degraded by physical, physiological and psychological immissions, which change the person's interior biological, chemical and mental balance. This can lead to totally different reactions in the same situation. One person might keep a cool, clear head and wait until the imminent danger or threat is over. The other person might break mentally and become incapacitated. Still another person might experience a total loss of self-discipline and self-consciousness, begin to panic and act in ways he would have never acted when unshaken. Finally, another person might, induced by fear and hopelessness, react bravely with courage and accomplish heroic deeds no one would have expected from him.

If one now looks at a section of combat very closely, one can focus on the single soldier and his weapon. Keeping the human parameters, and especially the combat soldier parameters, in mind the following illustrates how a short burst of fire onto human targets produces different effects on the soldiers in the target area at the same time. See Figure 5 and Figure 6 . In the configuration of Fig 5 the human targets have the same training, experience, morale and toughness.

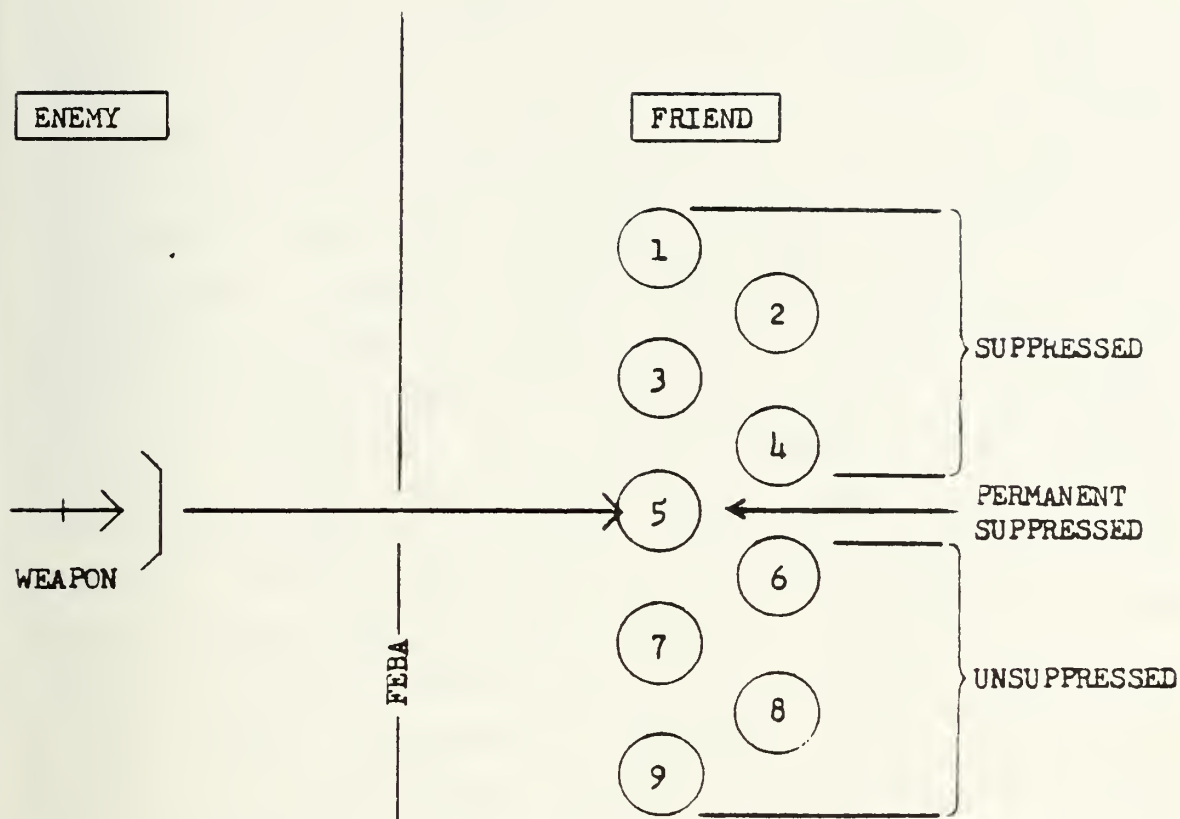


ALL TARGETS HAVE THE SAME TRAINING, EXPERIENCE, MORALE, TOUGHNESS

- A) TARGET EFFECT ON 5 = PHYSICAL EFFECT = PERMANENT SUPPRESSION
- B) TARGET EFFECT ON 3, 4, 7, 6 = PSYCHOLOGICAL EFFECT = SUPPRESSION
- C) TARGET EFFECT ON 1, 2, 8, 9 = NO EFFECT = NO SUPPRESSION

Figure 5 - EFFECTS OF NON FRAGMENTING FIRE ON HUMAN TARGETS WITH THE SAME INDIVIDUAL FACTORS. (SCHEMATIC)

It is obvious that a target that has been hit becomes damaged, wounded, or killed. In other words, it has become permanently suppressed. Thus, suppressed soldiers are closer and concentrically grouped around the impact of the fire than are the unsuppressed soldiers. This hypothesis can be substantiated by actual combat observations as well as by field experiments dealing both with fragmentation and non fragmentation weapons, as was done by Wesley W. Yale and Donald L. Mills [Ref. 10] and by Willard S. Vaughan, Jr. and Peyton G. Walker [Ref. 6] respectively. In the configuration of Fig 6 the targets have different training, experince, morale and toughness.



TARGETS HAVE DIFFERENT TRAINING, EXPERIENCE, MORALE, TOUGHNESS

TARGET 5, 6, 7 WITH MUCH
 TARGET 1, 2 WITH FEW
 TARGET 3, 4, 8, 9 WITH NORMAL

TRAINING, EXPERIENCE, MORALE, TOUGHNESS

- A) TARGET EFFECT ON 5 - PHYSICAL EFFECT - PERMANENT SUPPRESSION
- B) TARGET EFFECT ON 1, 2, 3, 4 - PSYCHOLOGICAL EFFECT - SUPPRESSION
- C) TARGET EFFECT ON 6, 7, 8, 9 - NO EFFECT - NO SUPPRESSION

Figure 6 - EFFECTS OF NON FRAGMENTING FIRE ON HUMAN TARGETS WITH DIFFERENT INDIVIDUAL FACTORS. (SCHEMATIC)

Observations in combat confirm that soldiers with better developed qualities of a soldier or combatant parameters become suppressed at a later time, if at all, than soldiers with less developed combatant skills. Other human qualities like intellect cause soldiers to react quite differently. Reasoned or rational suppression might begin sooner in intellectual persons because rational analyzation of the situation may signal a real danger. Combat observations support evidence that mentally untrained or naive soldiers were often suppressed to a lesser degree than educated soldiers. This was mainly due to the fact that these individuals often had a less clear understanding of the potential danger and thus did not perceive the threat situations when they in fact existed. This can also be supported by the findings of Mitchell M. Berkun [Ref. 11] in a report about performance decrement under psychological stress. The suppression threshold of soldiers with combat experience, good training, morale and toughness seems to lie at a higher level than for soldiers without it. The before mentioned report of Col. Wesley W. Yale and Donald L. Mills [Ref. 10] indicates that the combat experience of soldiers allows closer neutralization proximities than it does for those with less, or no, combat experience. Yet these soldiers suffer the fewer losses.

This common observation in war is because they can act together more harmoniously as a combat team and thus fire more effectively than unexperienced and untrained soldiers. They also are able to anticipate better certain enemy actions or reactions. The experience factor of how lethal different enemy weapons are and thus how safe the soldier still is, despite incoming fire, makes up the great advantage battle seasoned troops have over "greenhorns". The more the enemy's actions can be anticipated, i.e. the more his actions are predictable, the less he appears frightening because the mind can readily deal with the situation to come.

Generalmajor a.D. F.W. von Mellenthin² pointed out that unanticipated German actions at the Eastern Front had catastrophic impact on the Russian troops, for they could not cope with the shock of surprise. Only troops with high morale were able to do so. Later on the Western Front the Americans were not feared very much by the Germans despite the American technological and material superiority, because they were too predictable.

Many of the successes of the German Army in WWII, though mostly outnumbered by the Allied Forces in manpower and material, suggest a conclusion similar to Colonel (USA, Ret.) T.N. Du Puy's³ statements during his report on his Quantified Judgement Method, that superior leadership, combat soldier qualities such as high spirit, experience and training and combat unit qualities as esprit de corps can offset the effectiveness of enemy fire and increase the effectiveness of one's own fire. It should be remarked at this point that tactical manuals are based more or less on that principle and that all military education and training is aimed to develop these qualities.

Physical effects of a bullet or shell hitting a soldier can not be reduced by his actions. A soldier hit is attrited or wounded and therefore permanently suppressed. Employing his military skills and acting according to the situation he may, to a certain degree, decrease the probability of become hit. Good training, experience, morale, toughness and an existing willingness to fight and not to give up will aid in his survival.

² During an interview with the author on may 15th, 1979 in Monterey, California. From Nov. 1942 - Sept. 1944 on the Eastern Front, Major General (Ret.) F.W. von Mellenthin was Chief of Staff of the 48. Panzer Korps and later 4. Panzer Armee.

³ During a presentation of his Quantified Judgement Method (QJM), at the US Naval Postgraduate School in Monterey, California, March 5th and 6th 1979. Colonel (USA, Ret.) T. N. Du Puy is Executive Director of the Historical Evaluation and Research Organisation (HERO), a subsidiary of T.N. Du Puy and Associates.

Having avoided a direct hit and its physical effects, the impact will still produce a psychological effect.

Physical and psychological effects are the result of human beings in an operational environment exposed to target effects. Attrition, wounds, damage, and suppression are the physical and psychological effects respectively, resulting from combat. Since these combat effects are dependent on the combat inputs it may be concluded that fire superiority can also be described in terms of combat outputs. In battle the gaining of fire superiority is determined when enough enemy soldiers are killed or wounded, enough material has been damaged and enough enemy soldiers have been suppressed so that the enemy can not further or temporarily engage in combat. The term enough is of course only the common language description of the quotient of the actual fire effectiveness of enemy and friend. Fire superiority in the theoretical model thus could be represented in either of two ways. It could be done in terms of combat inputs or combat outputs.

It will have been noted that the human parameters received very strong attention. This is because they are so complex, poorly understood and very influential on combat. They can not be put away with only a few words. The large number of suppression studies reflects the interest in the human component in battle. Therefore it is only logical to attempt an association with other factors to find out how these factors are interrelated.

It is perhaps interesting to note at this point, that also equipment, e.g. radar, although having nothing in common with psychological effects, can be suppressed. This happens when Remotely Piloted Vehicles (RPV) cruise in the proximity of a suspected enemy radar tracking station. When the radar emitter beams signals the RPV also receives this signal and zeroes in. Since the RPV can cruise for several hours it can harass or even suppress the enemy radar activities, thus rendering the missile site ineffective.

E. HUMAN PARAMETERS IN COMBAT

In literature, battles have been narrated or reconstructed numerous times. Sometimes they have been described in minute detail, listing numbers of weapons, personnel and all the rest of the relevant military details. But seemingly they all do not represent the human aspect with the same exactness, though single heroic actions are often mentioned. Battles in which fire superiority have been gained by bare firepower will not be presented. Standard cases of this kind can be found in John Ellis book "The Social History of the Machine Gun". [Ref. 12] Instead examples shedding light on cases not so obviously involving human parameters and producing human or psychological effects will be presented.

The most striking example for suppression in its worst form, in fact so bad that the affected individuals might have to undergo psychiatric care is S. L. A. Marshal's [Ref. 5] description of suppressed American soldiers on Omaha Beach on the afternoon of D - day, June 6, 1944:

They lay there motionless and staring into space. They were so thoroughly shocked that they had no consciousness of what went on. Many had forgotten that they had firearms to use. Others who had lost their firearms did not seem to know that there were weapons lying all around them. Some could not hold a weapon after it was forced into their hands..... Their nerves were spent and nothing could be done about them.

This example might help to illustrate further what was previously described in the chapter dealing with suppression.

An example which underlines how important leadership, morale and all the other human factors involved are, is the description of an episode in the Polish Campaign in WWII*:

After the 4. Panzer Division, together with the attached "SS Leibstandarte Adolf Hitler" (an elite unit), had penetrated into Warsaw and had been embraced by Polish troops, one bad news followed the other. We were inferior in respect to forces, had been cut off and were suffering heavy casualties. ...We all at the Division Headquarters were tired to death following the several days long fighting and General Reinhardt, the Division Commander, shouted in a momentary weakness caused by extreme overload and stress: "This is too much, this is too much". ...Seconds later, Sepp Dietrich, the commander of the Leibstandarte which also had been fighting with the courage of the desperate entered the Division Headquarters and reported to the General: "Herr General the Leibstandarte is totally exhausted, you have to draw it back." Reinhardt said nothing for a short moment, looked deep into his eyes, stepped towards him and hit his flat hand on his shoulder saying: "Sepp - Do you know who is the opponent of the Leibstandarte?" - "No Herr General." - "The Leibstandarte Pilsudsky." Dietrich flinched, raised himself, viewed the General shortly with understanding eyes and replied simply: "Herr General, I thank you. The Leibstandarte will hold the positions." The Leibstandarte actually held position and at the next morning the crisis had been solved.

This episode addresses almost all aspects of the human parameters and serves as an excellent example of a leader's personality, his self-control, as a master of the situation and a model to his men. The mood of the soldiers was degraded by the experience of failure. Self-confidence and the feeling of being elite was lost because of the heavy casualty toll and the unexpected tough situation. After they were told that the enemy was also an elite unit who knew how to fight, their spirit and motivation was reestablished as well as their self-confidence. This restored their elite feeling and trust in their own abilities since they now knew why their efforts were so ineffective. They were literally spurred on to beat the enemy and did it. A psychological effect inverse to suppression must have been affected in this case.

* This example was excerpted from a letter (dated May 1, 1979) to the author by his father, H.W. von Fabeck, Colonel, Federal German Army (Ret). At the time of these events in September 1939, v. Fabeck was Major and Adjutant of General Reinhardt, Commander of the 4. Panzer Division.

The last example, a description of a situation at the Russian Front in WWII⁵, shows how a feeling of superiority can arise from superior fire and success.

Our field fortifications at the Wolchow frontline were built very nicely and thoroughly, yielding good cover and relatively good observation. My battalion was decimated to only 7 Officers, 234 NCO's and enlisted men, but we had, apart from artillery, which was used only in emergency cases, 96 machineguns, including booty weapons. This gave us enormous fire power, though we had to defend about 5.5 kilometers of frontline against an enemy who could not use tanks because of the swampy ground. All enemy attacks could be repelled successfully during this four month mission, leading to a build up of a superiority feeling in the men despite our insufficient and outnumbered forces. The daily artillery and grenadethrower attacks didn't cause too much harm to us in the swampy area and had almost no influence on the spirit of the troops.

It must be emphasized that fire superiority can not be gained when the destructive fire of weapons is not available. The highest ranking human parameters cannot replace fire and cannot absorb the effect of fire. But coupled with correct tactical behaviour human parameters can reduce the direct and indirect effects of enemy fire and can increase the effectiveness of one's own fire.

⁵ This example was communicated to the author by his father in law, R. Hoerr, Chief of Police (Ret), in a letter dated May 15, 1979. The incident occurred in the late summer of 1943, when Hoerr was Captain and Battalion Commander of the Hamburg Police Battalion, which took part in the big defensive battles at the Eastern Front.

III. THE FIRE SUPERIORITY MODEL

A. DEFINITION OF FIRE SUPERIORITY

The definition given above in section II A has provided an useful outline of the ideas concerning fire superiority. The report, Small Arms Weapon Systems (SAWS), of the U.S. Army Combat Developments Experimentation Center, Fort Ord [Ref. 13] states the following about fire superiority:

The purpose of the infantry fire fight is to gain fire superiority. Other factors being equal, small arms fire superiority prevents the enemy's fire or movement, permitting mission accomplishment. Achievement of fire superiority requires two elements:

1. attaining a greater magnitude of target effects than the enemy, as a function of time and
2. sustaining this level of target effects longer than the enemy can sustain his level of target effects and long enough to accomplish the mission.

Using the basic ideas of both definitions and including the input parameters as a descriptor of the scenario in which fire superiority is gained, fire superiority can conceptually be defined in the following manner:

FIRE SUPERIORITY IS A MORAL AND CULTURAL PHENOMENON THAT DEPENDS ON THE TACTICAL SITUATION, THE TECHNICAL HARDWARE AND HUMAN QUALITIES. IT IS RELATIVE, AND IS DETERMINED BY THE RATIO OF THE INSTANTANEOUS FIRE EFFECTIVENESSES OF ENEMY AND FRIEND. THE ACHIEVEMENT OF FIRE SUPERIORITY REQUIRES THE ATTAINING OF A CERTAIN MAGNITUDE OF PHYSICAL AND PSYCHOLOGICAL EFFECTS ON THE ENEMY AND SUSTAINING THESE EFFECTS LONG ENOUGH TO PREVENT THE ENEMY'S FIRE OR MOVEMENT, WHILE SIMULTANEOUSLY NEUTRALIZING THE PHYSICAL AND THE PSYCHOLOGICAL EFFECTS OF ENEMY FIRE.

B. PROPOSAL FOR A CONCEPTUAL MODEL

Based on the components and the definition of fire superiority and the relativity of fire effectiveness, a general model of fire superiority may be explained in the following way: Tactical, technical and human parameters together contribute to the build up of potential fire effectiveness in combat. The potential fire effectiveness is the inherent physical threat to the enemy. In the instant of drawing fire this fire effectiveness may be degraded (by the influence of the enemy's human parameters) to instantaneous actual fire effectiveness. For the enemy, the actual fire effectiveness is the perceived threat which he can not offset anyfurther. The same things happen simultaneously on the friendly side, so that the "crossover" of the fire apparently makes up the gaining of fire superiority. This was previously suggested in figure 2. Fire superiority thus may be expressed as the integral over time of the ratio of friendly and enemy instantaneous actual fire effectiveness:

$$FS = \int_{T=0}^{T=t} \frac{AEf}{AEe} dt$$

FS : Fire Superiority

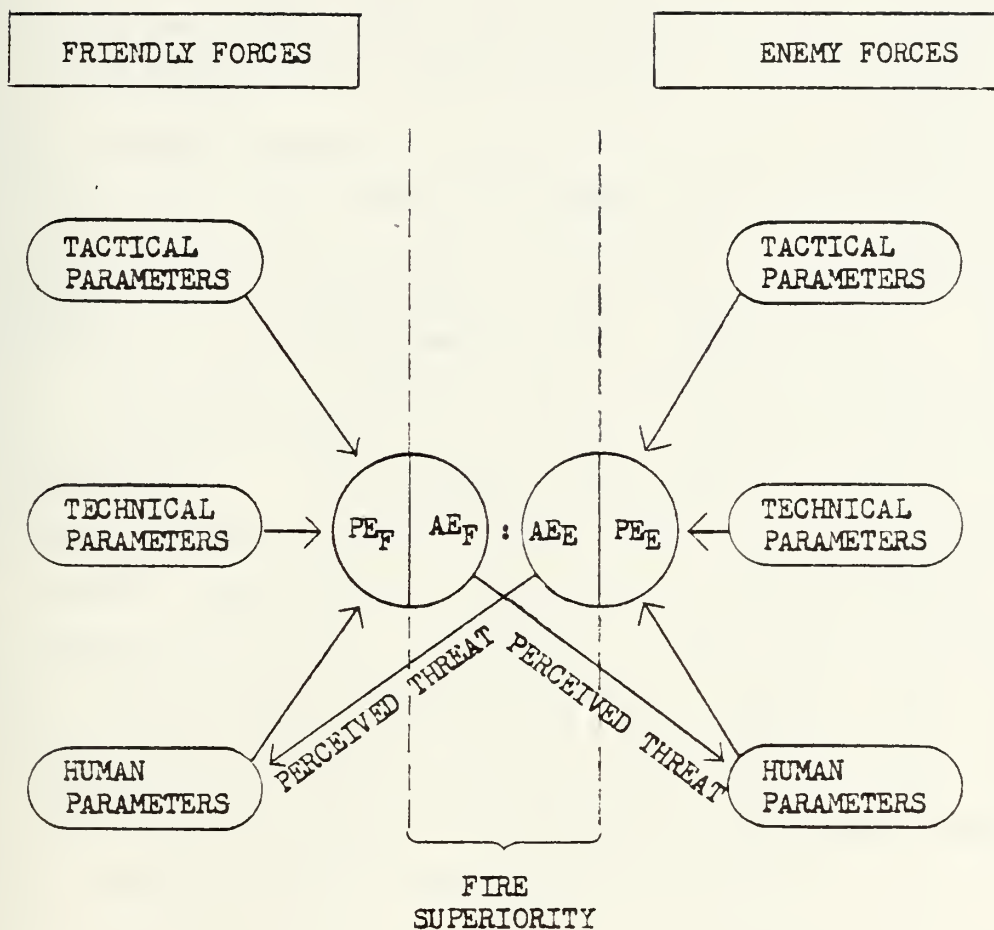
AEe : Actual Fire Effectiveness (Enemy)

AEf : Actual Fire Effectiveness (Friend)

T=0 : Time when combat starts

T=t : Time when combat ends

The concept of the "crossover" of the actual fire effectiveness is illustrated in Fig 7.



PE_F = POTENTIAL FIRE EFFECTIVENESS (FRIEND)

PE_E = POTENTIAL FIRE EFFECTIVENESS (ENEMY)

AE_F = ACTUAL FIRE EFFECTIVENESS (FRIEND)

AE_E = ACTUAL FIRE EFFECTIVENESS (ENEMY)

Figure 7 - FIRE SUPERIORITY, QUOTIENT OF THE ACTUAL FIRE EFFECTIVENESS

Note that the center between the two vertical dashed lines includes only the actual fire effectiveness of the opposing forces. The potential fire effectiveness is not included.

Since Fig 7 shows symmetry in the model it is sufficient to consider only one side in figure 8, in which greater detail of the components of fire superiority is depicted. The following model illustrates, in general, the descriptive part of chapter II, "Components of Fire Superiority". The model is organized in a manner that every term consists of determining subsets, exactly in the way a tree diagram would show dependencies. Furthermore the sets and subsets are arranged consistently so that they, when read vertically along a column, constitute a collection of equal ranking or equally important factors in combat, which all together determine the gaining of fire superiority. Where terms are not filled in, the horizontal dotted lines indicate that the terms placed further to the left also fall into all the next categories. It is necessary to distinguish between combat inputs and combat outputs, the latter being denoted by round brackets.

In order to avoid misinterpretation of this conceptual model it must be emphasized that Fig 8 must be read in the context of Fig 7.

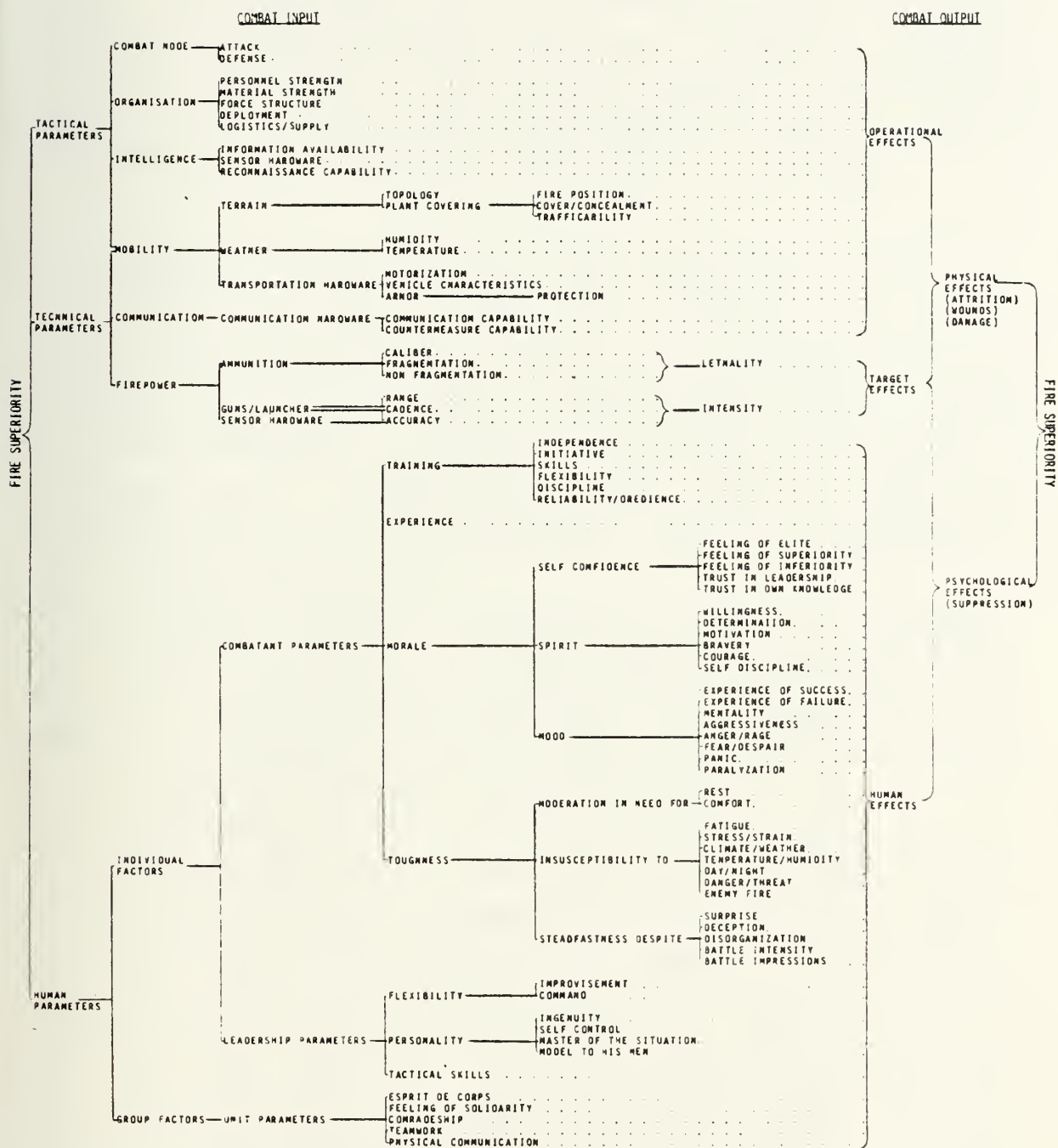


Figure 8 - THE OVERALL PICTURE OF FIRE SUPERIORITY

During the development of this conceptual model it has been assumed for organizational reasons not to show all possible interdependencies of the different factors. It is implied that the reader has a basic feeling for it since it seems to be logical, if not obvious, where this is the case.

C. RELEVANCE OF THE COMPONENTS FOR MODELING

The goals which have been set for an analytical model determine the model input. These goals might state a required resolution, accuracy, simplicity or amount of available input. Depending on the scale of combat the conceptual model of fire superiority offers a variety of application possibilities.

For small-scale combat at the platoon level, for example, this model provides very good resolution because of the amount of detail included. The amount of information might make the model clumsy but it could give more justification to the results in the eyes of non-modelers.

For large-scale combat the model is still applicable. In this case one will have to back up from too much detail provided by the 'right' columns of the model and go back to the 'left' two or more steps in the subset classification. The model will still provide enough detail which can be utilized with a manageable amount of work. The essence of what has been said is: The more accuracy one wants, the more information that is needed, and the more work that is required. Going from the right to the left side of the model decreases the number of input variables but increases the accessibility. Since the three basic parameters, tactical, technical and human parameters are represented in some form in each 'column', care is automatically taken that each parameter group will be reflected in a modeling attempt.

IV. CONCLUSIONS

The goal of this thesis has been to contribute to a better understanding of combat by analyzing the factors involved in the gaining of fire superiority. Having found a way to conceptually order these factors, it has become obvious that military OR analysts have not considered human factors in their combat-modeling efforts. The process of gaining fire superiority is a complex one, heavily dependent upon human factors in a given combat situation. All the complexities of human reactions, emotions, training, experience, morale etc. increase the difficulty in modeling fire superiority. Early simple combat models did not include human factors, and when they later tried, they only accounted for suppression processes. Suppression has been modeled and simulated in various ways in attempts to have more reality in the models. These attempts were all considerable improvements compared to their predecessors. However, models not including human factors do not seem elaborate enough to reflect greater reality. The contribution of this thesis is to be seen from the point that it might provide a basis for more reality in future modeling.

Follow-up work on this topic is highly desirable. It could use this thesis as a point of departure and translate the conceptual model presented here into an analytical one. This does not mean that one can expect to ever model the "real thing". However, with a reasonable amount of work one might develop a realistic model. However, difficulties in the quantification of all the human parameters still obstruct the way to a straight forward and 'easy' model. Future work, including a more realistic assessment of combat, will hopefully help the military analysts and planners to accept results of models more readily.

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